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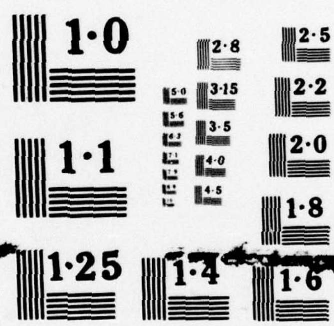

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NUCLEAR HARDNESS SURVEILLANCE FOR AN AIR FORCE WEAPON SYSTEM

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Presented to

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Third Annual Vulnerability/Survivability Symposium
Naval Amphibious Base
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NUCLEAR HARDNESS SURVEILLANCE
FOR AN AIR FORCE WEAPON SYSTEM

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FOR AN AIR FORCE WEAPON SYSTEM

by

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AMERICAN DEFENSE PREPAREDNESS ASSOCIATION

THIRD ANNUAL VULNERABILITY/SURVIVABILITY SYMPOSIUM
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Hardness Surveillance for major Air Force weapon systems is discussed. The Hardness Surveillance Program consists of an integrated set of periodic tests and inspections designed to detect degradations caused by aging, environment, operation or inadvertent maintenance and repair error which may compromise system survivability against nuclear attack. The purpose of the program is to detect degradation in time to facilitate corrective action before the hardness degradation is widespread.

The Surveillance Program is based on tests and inspections conducted in the field, at maintenance and repair depots, and in the laboratory. The program is oriented towards known or suspected degradation modes that could compromise system survivability. Depending upon the specific nuclear weapon produced environment (blast and shock, electromagnetic pulse (EMP) and nuclear radiation) testing is conducted at optimum levels of assembly.

Initial results of recently implemented surveillance program elements related to the environments of nuclear radiation are presented. Typical methods of analysis are illustrated describing how data may be analyzed for degradation trends and how the expected service life of the hardware is predicted. This information in turn provides the rationale for corrective action in a timely manner.

BACKGROUND

Weapon systems, e.g., Minuteman, are designed, produced, and utilized to perform certain operations to meet certain criteria and objectives. In the case of Minuteman, the weapon system was designed, fabricated, upgraded, and deployed to satisfy specific operational capabilities including nuclear survivability, the ability to successfully execute a mission while being exposed to the hostile effects of nuclear weapons. Whether or not the system, as the missile awaits use in the silo, is ready to meet all requirements is extremely important information relative to our country's defense posture.

This question of whether or not the system hardware will perform all functions critical to the mission may be measured in terms of weapon system effectiveness. Minuteman weapon system effectiveness plays a vital role in our country's national policy of deterrence of nuclear war and is an essential element in the Joint Chiefs of Staff Single Integrated Operating Plan (SIOP), the top tier plan for our defense. The requirement exists, therefore, for long term comprehensive efforts to maintain weapon system effectiveness for the duration of Minuteman deployment. The requirement also exists, consequently, for a long term program to quantify weapon system effectiveness as it currently exists for the lifetime of the system, for only through measured quantities does system effectiveness have real meaning and utility for SIOP.

The effectiveness of a weapon system is defined as a measure of the probability that the system will perform satisfactorily upon demand. The magnitude of this effectiveness is determined by probabilistic answers to the following questions:

1. Is the system ready to perform its mission; i.e., is it available?

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2. How well will the system perform during its mission; i.e., is it dependable?

3. Will the system produce the desired effects; i.e., is it capable?

The system effectiveness is the product of these probabilities of availability, dependability, and capability. Each of the major element probabilities in turn involves the product of subelement probabilities. For example, the probability that the system is available is the product of (1) its availability in a non-hostile, prelaunch environment and (2) its survivability in a hostile, prelaunch environment. And, the probability that the system is dependable is the product of (1) mission reliability in a non-hostile environment, (2) mission survivability in a hostile environment, and (3) penetrability.

The requirement for SIOP support results from the fact that continued successful SIOP development is dependent upon quantitative data from which the system's availability, dependability, and capability can be determined. Data from Logistics Support activities are inadequate for this purpose because they are primarily go/no-go data representing a relatively small percentage of the total system. Data to support SIOP must be obtained, however, because many of the key system effectiveness subelements (e.g., nuclear survivability) are rarely, if ever, exercised and have few, if any, built-in self-checks. Minuteman sits relatively undisturbed for long periods of time during which degraded availability, dependability, and/or capability could go completely undetected.

Without a program to determine hardness parameters throughout weapon system lifetime, only partial information would be available to determine system effectiveness. Non-hardness related parameters, e.g., reliability and accuracy are obtained by flight testing/analysis and other measurements. But, there is no way, under present political restraints, to actually test nuclear hardness parameters, since nuclear weapon tests are not allowed. In addition, criteria nuclear weapons exposures for some nuclear environments are degrading so that hardware so tested could not be replaced in the inventory for future use.

So, for both technical and political reasons, full scale testing of nuclear hardness is not feasible. However, there are sound technical approaches to surmount this problem. Tests are made in simulated environments at much less than criteria levels. Provided that failure mechanisms are well understood, such testing provides high confidence in weapon system survivability under low level nearest neighbor attacks and somewhat lesser confidence in weapon system survivability under high level direct attacks. Thus, simulated environment testing at less than criteria levels is the basis for the program to continuously update weapon system effectiveness testing to support SIOP. This is the Minuteman Weapon System Hardness Surveillance Program.

INTRODUCTION

The Minuteman Hardness Surveillance Program is an extended program of periodic tests and inspections designed to detect degradations in the hardness of the operational system which would not be otherwise identified during routine functional testing. These tests and inspections are required because hardness degradation can occur independently of the capability of the system to function in a non-hostile environment.

Hardness degradation of fielded systems can result from aging, environment, operational stresses and the effects of maintenance and repair. In this regard, maintenance and repair includes all field and depot activities other than system monitoring. Among these activities are handling and transportation, installation and removal, and assembly and disassembly.

The intent of Hardness Surveillance tests and inspections is to detect hardness related degradations in deployed hardware in a manner timely enough to permit corrective actions and preclude the occurrence of unacceptable levels of hardness degradation. A basic premise of the Minuteman Hardness Surveillance Program is that the weapon system, as fielded, satisfies applicable hardness requirements, and that baseline data exist with respect to hardness related performance characteristics. Minuteman hardware was designed and demonstrated to meet hardness requirements.

Given this baseline of acceptable hardness, the periodic tests and inspections performed under Hardness Surveillance provide an on-going evaluation of hardware with respect to the established hardness baseline. If the accumulated data for any given tests or inspections indicate trends towards unacceptable hardness levels for the hardware under evaluation, corrective actions are recommended.

The program described in this paper was developed (as described in Ref. [1] for the Guidance and Control System) by the Air Force Systems Command (SAMSO) with support from the original design contractors. Basically, the development consisted of (1) identification of non-nuclear degradation mechanisms which could cause degradation of hardness design features of launch essential/mission critical hardware items, (2) identification and prioritization of those hardware items which can degrade in a

non-nuclear environment and thus degrade hardness, and (3) definition of a candidate list of tests and inspections which was then screened and optimized to meet technical, cost, and schedule constraints prior to implementation.

The resulting Hardness Surveillance Program which is described in Ref. [2], consists of inspections in the field and at maintenance and repair depots and the testing of various hardware assemblies both in the field and in the laboratory. Depending upon the specific hostile environmental effects, testing is conducted at cost effective levels of assembly from transistors and integrated circuits up to the entire Launch Facility. Data related to the continuing hardness of the system, whether generated specifically on the Surveillance Program or available from hardness maintenance or other efforts are acquired, stored, and compared periodically with previous baseline data. Statistical and other analyses are performed to estimate current system hardness based on the data base provided by the tests and inspections. The information and results generated provide up-to-date data on the "as-is" nuclear hardness of the weapon system during the operational phase of its life.

Surveillance is related to a number of programs which have been implemented to ensure that design hardness is maintained throughout the weapon life cycle - production, assembly and checkout, operation, maintenance and repair, redesign and reprocurement. All of these programs have, as their objective, the assurance of system nuclear hardness during the various operational phases. Surveillance is in essence the assurance program for the deployment phase of the weapon system.

This program is called Hardness Surveillance. Basically it is a program which monitors potentially degradable hardness-related hardware, detects degradation should it occur, defines the appropriate actions, and provides effectiveness measures of the corrective action required to preclude these degradations from creating a wartime vulnerability within the weapon system.

PROGRAM DESCRIPTION

The Surveillance Program as presently constituted represents the result of considerable evolution and development. Because of cost constraints, not all desirable tests and inspections are included, rather only those considered required. The mix of tests and inspections provides a high level of confidence for system survivability against nearest neighbor attacks, i.e., against those vulnerabilities existing under attacks which could kill more than one missile. The program also provides somewhat lesser confidence in weapon system survivability against direct attack.

The program is summarized in Tables I and II, for Field Activities and Depot/Test Facility Activities, respectively. As shown in Table I, the Field Test Activity portion comprises inspections, shock, mechanical, and electromagnetic pulse (EMP) tests; and sample collections. The inspections are intended to ensure the representativeness of the hardware for testing in addition to obtaining data on visually observable degradation. Shock and mechanical tests, of which Fig. 1 and 2 are examples, are designed to measure, in situ, the performance of hardware with respect to the shock and blast environments generated by nuclear weapons. EMP tests illustrated in Fig. 3, are to do the same with respect to the EMP environments generated. The sample collections are, as the name implies, activities of removing hardware for tests which are not performed in the launch complex.

Several of these latter tests are listed in Table II which includes all the testing/inspections not performed in the field. These are the tests and inspections (T/I's) which are more logically performed on hardware removed from the field. In addition, several of the activities address missile electronics aerospace vehicle equipment (AVE) hardness with respect to nuclear radiation environments.

PROGRAM STATUS

The Surveillance Program was carefully set up for efficient implementation. The program was developed by SAMSO, Air Force Systems Command for Ogden ALC, Air Force Logistics Command. For effective transition of responsibility, the program was divided into three phases with management responsibility assigned appropriately as shown in Table III. The overall schedule for the three phases, and management transfer are also shown in Table III. At the present time, November 1977, Program Management Responsibility Transfer (PMRT), is partially completed. This means that only some of the tests and inspections have been demonstrated by SAMSO, and have been accepted and are being implemented by Ogden. The master schedule showing the status of different T/I groups is presented in Fig. 4. As shown therein, the start of implementation is spread over approximately a year and a half. Consequently, at this time only a small part of Surveillance can be reported. Therefore, this paper is concerned only with those activities that have actually begun, i.e., Computer Radiation Tests, Piece Parts Radiation Tests, and the Field/Depot Surveys.

RESULTS

Hardness Surveillance is a test program, as indicated by the amount of effort required for testing, but the analysis and interpretation of

TABLE I

Surveillance Field Activities

<table>
<tr><th colspan="2" rowspan="2">Facility Identification</th><th colspan="6">TEST OR INSPECTION (T/I) IDENTIFICATION</th></tr>
<tr><th>Pre-Test Inspections</th><th>Shock Tests</th><th>Mechanical Tests</th><th>EMP Tests</th><th>Post-EMP Tests</th><th>Sample Collections</th></tr>
<tr><td rowspan="2">Launch Facility</td><td>Launch Equipment Room</td><td rowspan="2">Checklist Inspections</td><td>Floor/Rack Test</td><td>Tapped Thread Load Test
Spring Force Blast Valve Low-Level Test</td><td>Penetrations Test
Transmission Paths Test</td><td rowspan="2">Inspection of Drawer Interiors</td><td rowspan="2">Sample Collections
Foam Blocks
Elastomeric Springs
Shock Mounts
G&C Coolant</td></tr>
<tr><td>Launch Support Bldg.</td><td>Floor/Rack Test</td><td>Blast Damper Test</td><td>Power Line Penetrations Test</td></tr>
<tr><td rowspan="2">Launch Control Facility</td><td>Launch Control Center</td><td rowspan="2">Checklist Inspections</td><td>Floor/Rack Test</td><td>Blast Valve Low-Level Test</td><td>Penetrations Test
Transmission Paths Test</td><td rowspan="2">Inspection of Drawer Interiors</td><td rowspan="2">None</td></tr>
<tr><td>Launch Control Equipment Bldg.</td><td>Floor/Rack Test</td><td>Blast Valve Low-Level Test</td><td>Power Line Penetrations Test</td></tr>
</table>

TABLE II

Surveillance Depot/Test Facility Activities

Test or Inspection (T/I) Description	Test Articles
Semi-conductor Piece-Part Radiation Tests	Semi-conductors
Guidance & Control System Coolant Fungus Test	Coolant from Plumbing Set
Foam Block Static/Dynamic Compression Tests	Missile Suspension System and Launch Equipment Room Floor Foam Blocks
Elastomer Peel Test	Shock Mount of Launcher Distribution Panel
Elastomeric Spring Static and Dynamic Tests	Missile Suspension System Elastomeric Spring
Missile Guidance Set High-Level Prompt-γ Test	Missile Guidance Set
Flight Computer Low-Level Prompt-γ Radiation Test	Flight Computer
Depot/Field Inspections	Guidance and Control System

TABLE III

HSP Management Responsibility

Phase	Purpose	Responsibility	Support	Schedule
Definition	Define Program	SAMSO	Ogden ALC, SAC	74, 75
Preparation	Make Ready	SAMSO	Ogden ALC, SAC	Jan 76 - Jun 78
Implementation	Execute Program	Ogden ALC	SAMSO, SAC	Jul 78 and on

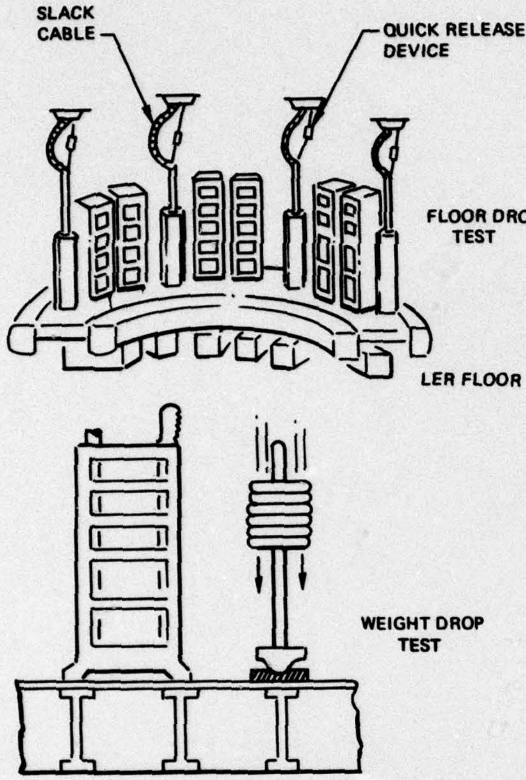

Fig. 1. Floor/Rack Shock Tests

test data are most important surveillance considerations. Since the program is designed not merely to detect problems, but also to detect incipient problems in the form of degradation trends before there is any impact on force capability, rigorous analysis is mandatory.

In general, it is expected that most of the data obtained under the program will be negative, i.e., showing no change, no hardness degradation. Therefore, a large percentage of the data handling is expected to be routine. However, in analyzing all data, trends will be searched for degradation indications. If trends are found, they will be examined for statistical significance, and predictions will be made as to the time at which the trend actually turns into a problem, i.e., service life estimates will be made. The general approach to trend analysis is shown in Fig. 5. The data will be plotted as shown with the measured variable against selected parameters, e.g., number of field hours, number of times repaired, etc. The chart will also contain alert and problem limits, derived from hardware specifications. Intersection of the statistically derived trend line (explained variation) and tolerance limits (unexplained variation) with alert or problem limits will guide the trade-off of options such as increased test frequency or increased sample size to verify the trend, or new tests or inspections, or some corrective action.

In addition, at the first indication of a problem, a system impact analysis will be performed to ascertain the seriousness of the problem of exceeding alert or problem limits. The analysis flow is illustrated in Fig. 6.

Only limited information is available for the analysis/utilization of data from specific T/I's at this time. Data are available from Depot/Field Surveys, Piece Parts Testing, and Flight Computer Radiation Testing. The first two T/I's are somewhat atypical in that they are planned for implementation on a one time only basis with future activities dependent upon the results/benefits from the first year's activities. The computer test results do however fall into the area of a typical Surveillance T/I, and are presented. One other T/I has been started. Blast valve test demonstrations have been performed and initial implementation has begun. However, the data analysis has not been completed in time for inclusion in this paper.

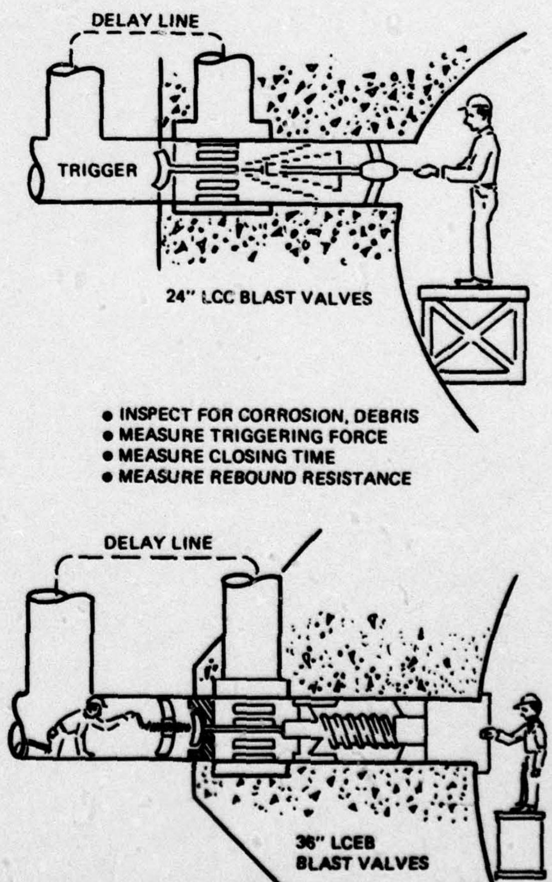

Fig. 2. Blast Valve Field Trigger Test

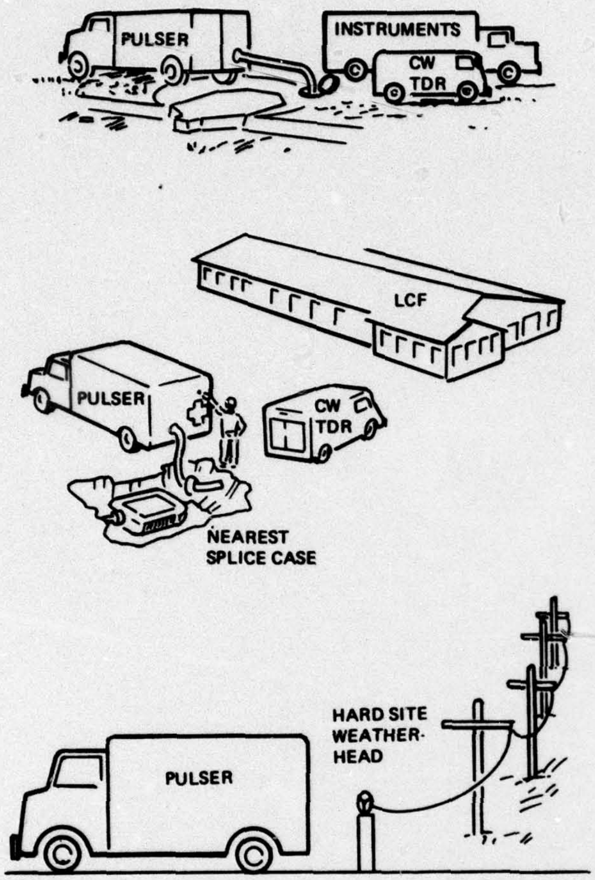

Fig. 3. LF/LCF EMP Tests

Depot/Field Surveys

Under the Minuteman Program maintenance concept, no repairs are performed at the operational sites on any electronic hardware. Replacement parts and modules may be installed, but defective hardware is returned to one of the two maintenance depots for repair. The two depots are Newark Air Force Station (AF Guidance/Metrology Lab) for the Missile Guidance Set (MGS) and Ogden Air Logistics Center for all other hardware. Procedures for all field and depot operations are thoroughly documented in Technical Manuals into which hardness considerations have been integrated.

Purposes of the surveys were to verify that hardness maintenance activities are sufficient to identify, prevent, and correct hardness deficiencies; that data, equipment, and training are adequate; and to identify areas of improvement. The survey team was composed of three members, one each representing radiation effects engineering, logistics engineering, and quality assurance engineering. The surveys were conducted by observing the handling, test, repair, and inspection activities and by detailed discussions with shop and management personnel.

No major problems were found at either depot. In general, and as was found in previous surveys conducted under Minuteman Production Hardness Assurance, maintenance personnel are qualified, cooperative, and have a basic understanding of hardness concerns. However, the survey team found that the survey itself tended to reemphasize hardness concerns and to reinforce awareness. Some of the discussions indicated that periodic hardness awareness training was necessary not only to take care of personnel changes but to serve as a reminder of past training.

In the hardware area, some minor problems were found as follows:

1. Corrosion deposits around coolant fittings and attach mounts in the MGS. (Neutralization procedures to prevent corrosion have been implemented.)

2. MGS handling equipment needed protective pad replacement to prevent scratching electromagnetic (EM) critical surfaces. (Pads have been replaced.)

3. Downstage cable EM test fixtures need refurbishment to prevent worn connectors from damaging flight hardware. (Connectors have been ordered.)

4. Flight computer gas fill system has potential for incorrect mixture fill. (A foolproof fill procedure is being developed.)

5. Some non-hard parts were in stock and need to be removed from system. (Parts have been removed.)

6. Hardness Critical Items (HCI's) are not so identified in the Technical Manuals and are therefore not always known by shop personnel. (Since changes in the manuals are inappropriate, supplementary documentation identifying HCI's has been provided.)

In summary, the surveys found Depot operations to be acceptable with only minor problems which were identified for corrective action. Thus, specific items to improve the reliability of force hardness were accomplished and the benefit of stimulating hardness awareness among program personnel was accomplished.

Piece Parts Testing

In general, the radiation hardness of electronic systems lies in the basic semiconductor

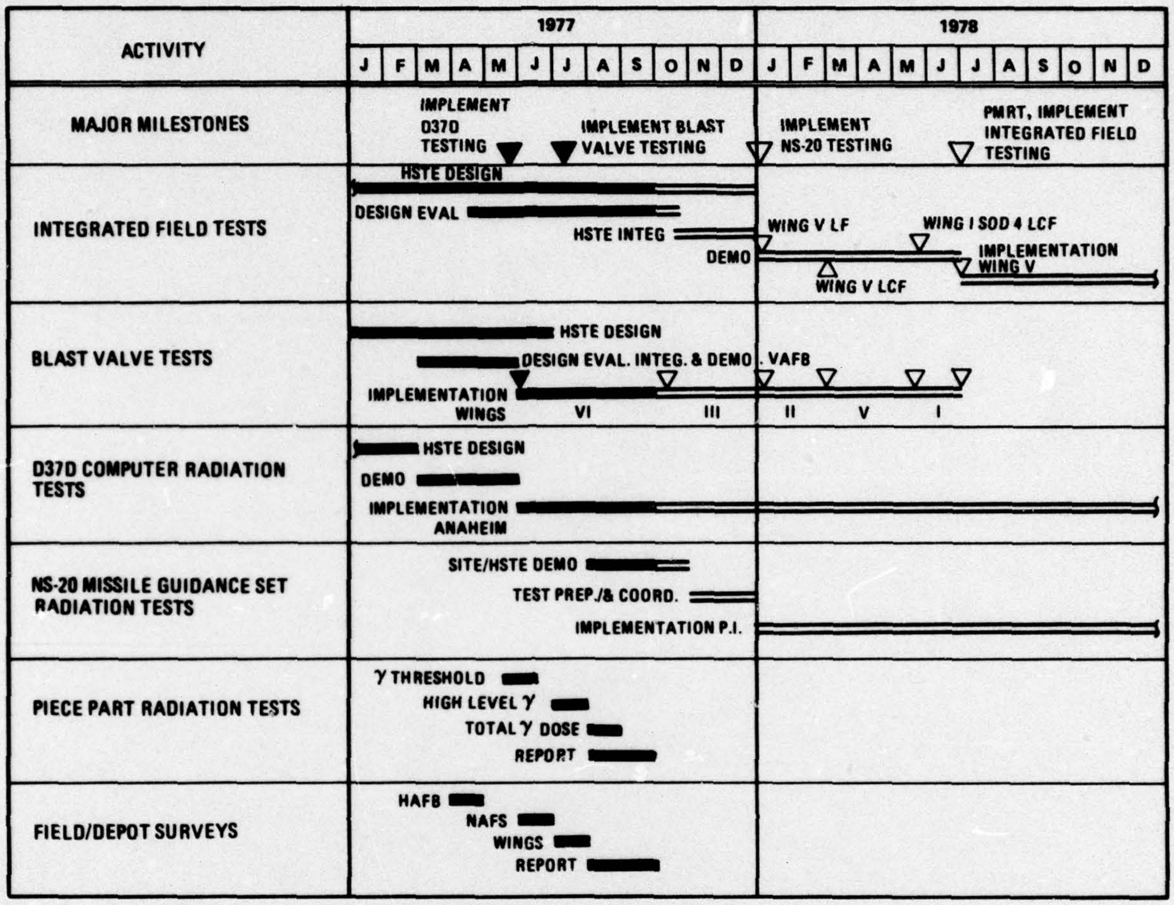

Fig. 4. Hardness Surveillance Program Schedule

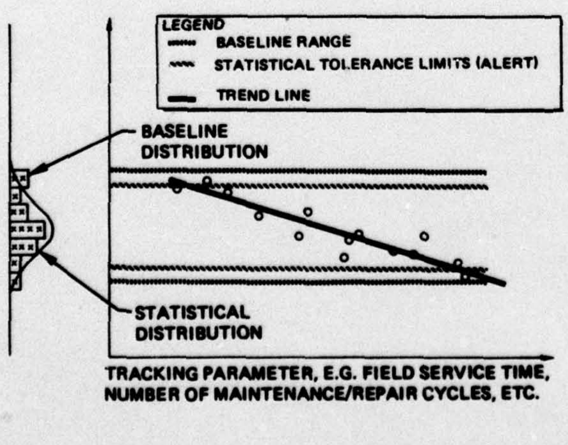

Fig. 5. Trend Chart

parts themselves. There are some circuit effects especially with those environments which produce transient effects but hardness is primarily an integral characteristic of piece parts. Consequently, any system hardness aging or degradation due to any cause must show up in the behavior of parts. And, the effects can be tested at the parts level of assembly.

The statement is especially true for those nuclear environments which produce permanent damage. Neutrons and total (integrated) ionization radiation dose produce permanent gain degradation in transistors while X-rays can produce thermomechanical damage. On the other hand, ionizing radiation and EMP environments produce transient effects in addition to permanent effects like burnout. In testing for such environments, the parts must be active and data must be accumulated during the actual test exposure. But in any event, piece part testing is a viable method of determining hardness aging or degradation.

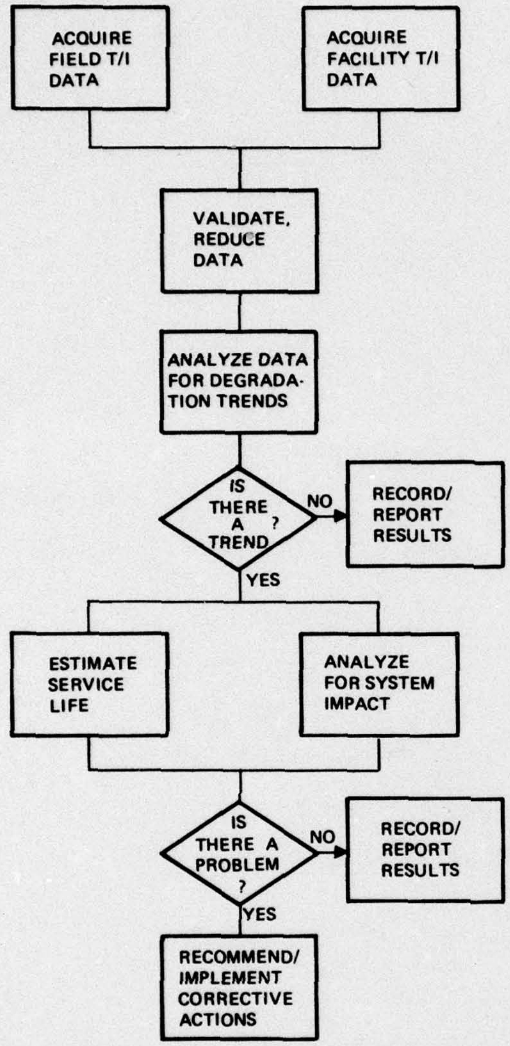

Fig. 6. Data Utilization Flow

Different margins of safety exist for the various nuclear environments. In the Minuteman System, the environment of most concern is the ionizing radiation environment, e.g., prompt gamma and X-radiation. Because of system design, parts response at both threshold and criteria levels is of interest as is the response of parts with respect to the total (integrated) radiation dose. Consequently, the piece parts test effort includes these three aspects of the ionizing radiation environment: (1) threshold level, (2) criteria level, and (3) total dose.

At the present time, only preliminary threshold gamma data are available for reporting. The testing is complete but the analysis is still being performed. High level gamma and total dose testing have just been completed.

The test samples were taken from a single missile guidance computer which had been fielded 4-1/2 years. In the Minuteman missile, the flight computer controls both the ground and airborne equipment and therefore is actually operating 100 percent of the time. Therefore, the parts had accumulated a total operating time of 35,871 hours. Any hardness degradation would be expected to show up if these data are different from data taken on similar parts when new.

The critical hardness parameters are primarily diffusion lot dependent so that parts from the same lot are essentially the same. Metallization lots and Q.A. or receiving lots only have a minor impact. Therefore, comparison of "aged" data is made with the same parameters measured on parts taken from the same diffusion lots when new (baseline data).

A total of seven part types were tested, two transistors and five integrated circuits with a minimum of 10 individuals of each part type. The part types are listed in Table IV.

The data are obtained in the form of measured photocurrent (current developed by the irradiation) as a function of dose rate. In general, photocurrent is proportional to dose rate, so a plot of values obtained should result in a straight line. Typical data obtained are shown in Fig. 7 and Fig. 8 for the Level Detector, Part Number 0530 and Fig. 9 for the Input Network, Part Number 0537. For each of the three figures, two sets of data were taken in 1971 and 1977, the former with the White Sands LINAC and the latter with the Ogden ALC LINAC. Excellent agreement of the two sets of data was obtained, indicating that operational life/usage and typical handling/maintenance/transportation, etc., did not have an adverse effect on hardness, at least for these samples. Data obtained with other parts, while not having such tight distributions, still yielded the same result, no evidence of hardness degradation with usage and aging. Thus, earlier work on Minuteman I and II transistors (Ref. [3] and [4]) which did not show evidence of aging/degradation has been reinforced. However, it should be remembered that lack of evidence of aging degradation is not the same as evidence of a lack of aging degradation. Consequently, these results cannot be extrapolated to other part types nor to other environments.

Missile Guidance Computer

The computer is the "brains" of the weapon system electronics. It not only controls the missile in flight but also controls and monitors the missile and all operational ground electronics while the missile is in the silo. Because the electronic system is susceptible to

TABLE IV

Semiconductor Parts Tested

Semiconductor Part Function (Name)	MM Part Designation	Equivalent Commercial Part Designation
PNP Silicon Dual Switch Transistor	472-0542	2N995
PNP Silicon General Purpose Transistor	472-0543	2243A
Low Level Switch	477-0527	None
Read Preamplifier	477-0528	None
Triple High Level Hand Gate	477-0529	None
Level Detector	477-0530	None
Input Network	477-0537	None

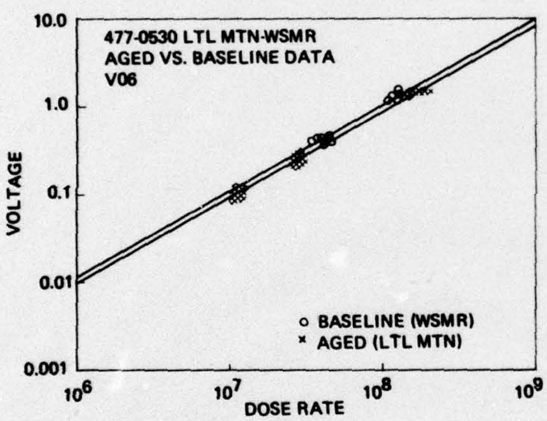

Fig. 7. Aged vs Baseline Data for the Level Detector, P/N 0530, V06

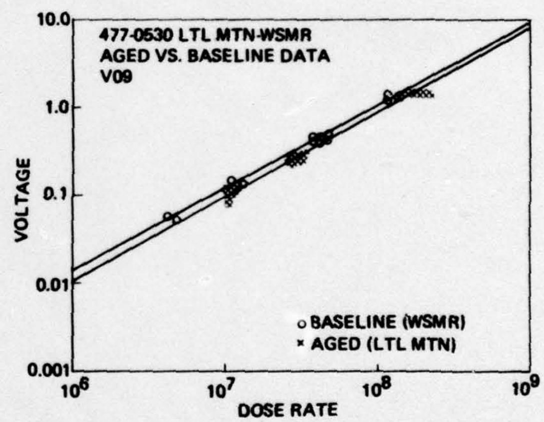

Fig. 8. Aged vs Baseline Data for the Level Detector, P/N 0530, V09

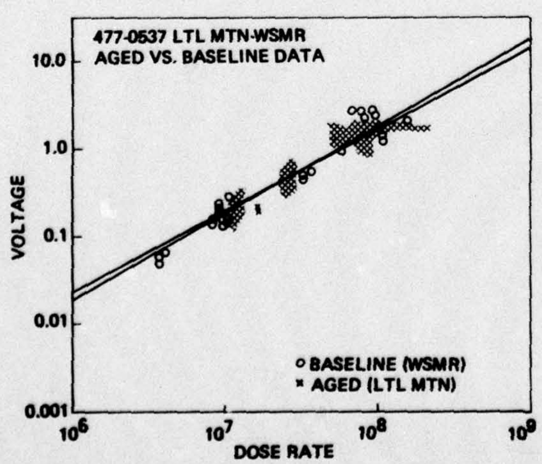

Fig. 9. Aged vs Baseline Data for the Input Network, P/N 0537

transient upset due to ionizing radiation the computer is mechanized to avoid the effects of exposure. The mechanization, termed circumvention, essentially puts the computer "to sleep" during the exposure. After the exposure is past, lost or missing data are recreated based on the most recent information contained in the memory. Circumvention is such that many exposures can be handled by the system without appreciable error being introduced into the missile trajectory.

The trip level for circumvention is set below the threshold for transient upset in the electronics. A radiation detection circuit, composed basically of a sensitive transistor, is used. The transistor is screened by flash X-ray testing to ensure that all computers have essentially the same trip level. However, the

error threshold is not fixed but is a variable subject to the characteristics of the most sensitive computer circuitry. In addition, the ratio between trip and error threshold is kept small since having a much lower trip level would tend to increase the number of circumventions and eventually have an accuracy impact. Therefore, because the two thresholds are close, changes such as increases in circumvention trip level or decreases in sensitive circuit error threshold due to aging handling or unknown causes could constitute a system vulnerability.

Under Surveillance, the computers are tested to assure the stability of the ratio of error to trip thresholds. The threshold ratio must be maintained at a level greater than one. Computers passing through the repair depot are selected for test based on several criteria including operating lifetime, rework of critical modules, certain production serial numbers where the production testing was less frequent, and other considerations.

In the test sequence, the computer is checked for functional performance. Then the circumvention trip level is determined by repeated exposures with a flash X-ray machine as shown in Fig. 10. The radiation level for 0 percent and 100 percent trips and several points in between are found. (Trip is a probabilistic event, and occurs at different levels depending upon what operation the computer is performing at the time of exposure.) The error threshold is determined in the same manner except that a lead shield is placed between the X-ray machine and the computer in such a manner that the circumvention detector is shielded but the sensitive electronics are directly exposed. If the threshold ratio is greater than one, the computer is functionally tested and returned to service. If not, semiconductor parts are replaced, the computer again tested and then returned to service.

The detailed analysis for each tested computer is illustrated in Fig. 11. The parameters of both trip and error response curves, including slopes and intercepts are calculated from the data. In addition, a new calculation of threshold ratio is made, i.e., error threshold divided by trip threshold. These five variables are then examined for trends.

The general form of trend charts is illustrated previously in Fig. 5. The measured parameter of interest is plotted against some independent variable such as total service life, chronologic age, number of times recycled for repair, etc. The plots are made for visual examination but the trends are obtained by statistical calculation of the least squares fit of the data. Where time or some variable related to time is the independent variable, the service life estimate is obtained from the intersection of the trend line and tolerance limits with specification limits and the known distribution of the independent parameters over the total population.

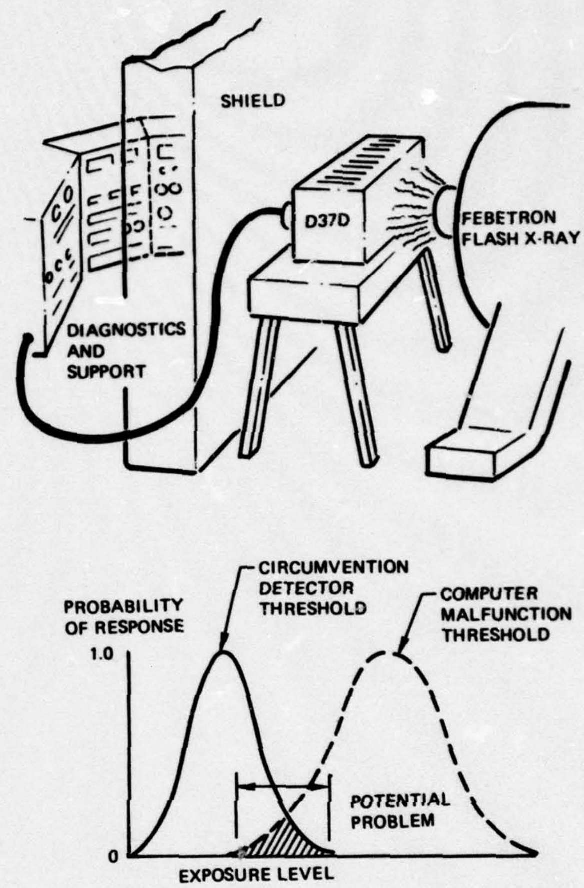

Fig. 10. D37D Low Level Prompt Gamma Test

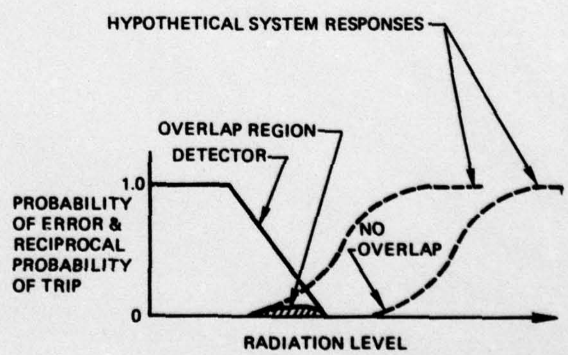

Fig. 11. Detailed Analysis for a Single Computer

Several plots of data on the computer are made. The data obtained prior to Surveillance implementation, which constitute the Surveillance baseline, were obtained from identical tests conducted as a part of the Production Hardness Assurance Program (Ref. [5]). The data obtained to date of which Fig. 12 is an example, show only a slight trend indicating little evidence of aging or degradation due to handling.

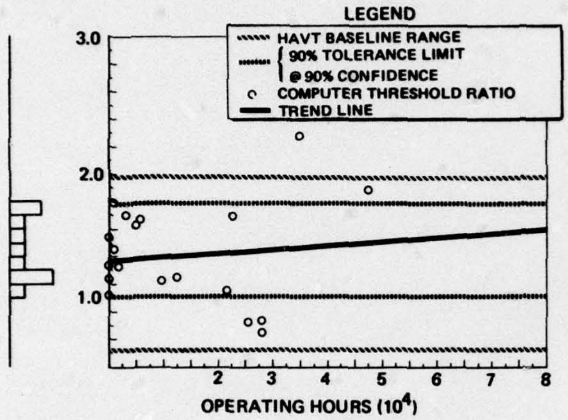

Fig. 12. Typical Computer Analysis Trend Chart

When the analytical results show no particular trend, the analysis is complete. However, the existence of any trend becomes the beginning of a more detailed analysis involving the estimation of service life for different levels of confidence, a hardness impact analysis for the system or subsystem under consideration, and the interpretation of force survivability, due to the hardness impact. This latter effort has as its purpose the definition of the meaning of the degradation trend to provide guidance of the corrective action required and the time to institute such corrective action.

SUMMARY AND CONCLUSIONS

A Surveillance Program has been initiated for the Minuteman Weapon System to provide confidence in the continuing hardness of the system. The program includes testing and analysis of various assemblies and subassemblies from the electronic piece part level to the entire Launch Facility. Level of assembly was selected by consideration of environment, cost, and information obtained.

The Program now in the initial implementation phase, is comprised of tests and analysis oriented to all environments of concern including blast, shock, vibration, EMP and nuclear radiation environments. The Program also includes inspection surveys of both field sites and maintenance depots. A major portion of the program field testing is yet to be started, but several tests/inspections primarily concerned with radiation hardness have been implemented and are discussed in this paper.

The initial results are encouraging both from the standpoint of yield of useful information and of the continuing hardness of the force. Initial test and inspection results have shown only a few rather insignificant problems, all of which have been fixed with minimum effort. No major problems have surfaced. On the other hand, the effect of Surveillance, by identifying problems and solutions, is making the force better than it would be without the Program.

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